Patent
Docket No. 200310817-1

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

APPEAL NO. ________________

In re Application of:
Nauka et al.

Confirmation No.1558

Serial No. 10/698,717
Filed: October 31, 2003

Group Art Unit: 2656
Examiner Van T. Pham

For: DATA STORAGE DEVICE INCLUDING CONDUCTIVE PROBE AND FERROELECTRIC STORAGE MEDIUM

APPEAL BRIEF

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1. REAL PARTY IN INTEREST

The real party in interest is the assignee, Hewlett-Packard Development Company.

2. RELATED APPEALS AND INTERFERENCES

No appeals or interferences are known to have a bearing on the Board's decision in the pending appeal.

3. STATUS OF CLAIMS

Claims 1-37 are pending in this application.

Claims 1-6, 8, 13-24, 27, and 30-37 are cancelled.

Claims 7, 9-12, 25-26 and 28-29 are rejected.

The rejections of claims 7, 9-12, 25-26 and 28-29 are being appealed.

4. STATUS OF AMENDMENTS

An amendment was filed on August 11, 2006, which is after the filing date of the Notice of Appeal, but before the filing of this Appeal Brief. The after-appeal amendment reduced the number of issues for appeal by cancelling claims 1-6, 8, 13, 21-24, 30, 27 and 36-37 and rewriting dependent claims 7, 9-12, 25-26 and 28-29 in independent form. An advisory action dated August 18, 2006 indicates that the after-appeal amendment was entered. The amended claims are listed in appendix A.

5. <u>SUMMARY OF CLAIMED SUBJECT MATTER</u>

Claims 7 and 9-12 all recite a data storage device comprising a conductive probe having a tip, a substrate including a semiconductor portion, and a data storage medium. The data storage medium includes a layer of poled ferroelectric material for storing data. The ferroelectric layer is on the substrate, between the tip and the substrate. The semiconductor portion and the ferroelectric layer form an electrical junction.

An exemplary data storage device 110 is illustrated in Figure 1 and described in paragraph 15 of the specification. The device 110 includes an array of conductive probes 112, a substrate 114, and a ferroelectric storage medium 116. The ferroelectric storage medium 116 includes a layer 118 of poled ferroelectric material. The poled ferroelectric layer 118 is on the substrate 114, between the substrate 114 and tips of the probes 112. The ferroelectric layer 118 functions as a ferroelectric storage medium or data recording layer.

According to paragraph 16, the ferroelectric layer 118 is poled to order its electrical dipoles in a uniform direction, and to define one of the binary states for the storage of information. Figures 2a and 2b illustrate the dipoles 210 in the ferroelectric layer 118 before poling and after poling.

Claims 10 and 25-26 also recite the "Curie temperature" of a ferroelectric material. According to paragraph 17 of the specification, the Curie temperature of the ferroelectric material is the maximum temperature at which dipole alignment is maintained. If the ferroelectric layer is exposed to a temperature above the Curie temperature, the dipole polarization of the layer will become randomized.

Claims 7 and 9-12 recite separate features of the data storage device. Claim 7 recites a protective layer covering the ferroelectric layer. The protective

layer does not interfere with interactions between the probe tip and the ferroelectric layer. An exemplary protective layer is referenced by numeral 122 in Figure 1 and described in paragraph 19. According to paragraph 25, the protective layer 122 offers the added advantage of allowing the probes 112 to be dragged across it instead of the ferroelectric layer 118. The probes 112 damage the protective layer 122 instead of the ferroelectric layer 118. Thus, the protective layer 122 can also function as a sacrificial layer.

Claim 9 recites a circuit for causing the conductive probe to perform block and bulk erasure operations. Paragraph 30 describes an example of a block erasure. A block erasure can be performed by dragging the probe tip along the ferroelectric layer 118 across multiple bits 413, while the circuit 120 (in Figure 1) applies a constant voltage bias to the probe 112 to restore the initial polarization of the bits.

Examples of bulk erasure are described in paragraph 31 of the specification. Bulk erasure may be performed by dragging the probe tips, or by heating the ferroelectric layer 118 above its Curie temperature and cooling off the ferroelectric material to room temperature in the presence of a poling field. The heating may be performed via joule heating or radiant heating. For example, one or more resistive heaters 510 may be located at the back of the substrate 114, as shown in Figure 5. Multiple heaters could be assigned to sections of the substrate 114. The heaters 510 can be selectively turned on to erase blocks of bits 413.

Claim 10 recites a means for heating the ferroelectric material above its Curie temperature. According to paragraph 31 of the application, the heating may be performed via joule heating or radiant heating. For example, one or more resistive heaters 510 may be located at the back of the substrate 114, as shown in Figure 5. Multiple heaters could be assigned to sections of the substrate 114.

Claim 11 recites a read circuit for using a probe to sense changes in capacitance or leakage current of the junction. An exemplary read circuit is referenced by numeral 120 in Figure 1, and an exemplary method of using the read circuit is described in paragraph 33 and illustrated in Figure 6a. As a probe 112 is scanned along the ferroelectric layer 118 (block 610), the circuit 120 uses the probe 112 to sense local changes in properties of the junction induced by the dipole polarization (block 612). For example the circuit 120 can sense changes in junction capacitance or junction leakage current. These changes indicate whether polarity reversals occur at the bits.

Another example of detecting leakage current is illustrated in Figure 6e and described in paragraph 28. A probe 112 is scanned along the ferroelectric layer 118 (block 650) while a bias is applied between the probe 112 and the substrate 114. The circuit 120 senses a leakage current flowing through the ferroelectric layer 118 (block 652). Magnitude of the leakage current is modulated by the polarity of the bit being scanned 413, and thus can indicate polarity reversals.

Claim 12 recites a read circuit for using the probe to apply an ac signal to local areas on the ferroelectric material, and detect changes in a non-linear component of a dielectric constant. An exemplary read circuit is referenced by numeral 120 in Figure 1, and an exemplary method of using the read circuit is described in paragraph 34 and illustrated in Figure 6b. A probe 112 is scanned along the ferroelectric layer 118 (block 620), and the circuit 120 uses the probe 112 to apply an ac signal to local areas on the ferroelectric layer 118 (block 622), and detect changes in the non-linear component of its dielectric constant. The circuit 120 can detect the changes by sensing a shift in capacitance phase of the junction (block 624). The capacitance shifts indicate the polarity reversals.

Claims 25-26 and 28-29 recite method claims. Claim 25 recites a method of writing information to a layer of poled ferroelectric material. The method includes heating the ferroelectric layer above its Curie temperature. An example of such a method is described in paragraph 31 of the specification. The ferroelectric layer may be heated above its Curie temperature and then cooled off to room temperature in the presence of a poling field. The heating may be performed via joule heating or radiant heating. Block or bulk erasure may be performed according to this method.

Claim 26 recites a method of writing information to a layer of poled ferroelectric material. The method includes heating selected areas of the ferroelectric layer above the Curie temperature of the ferroelectric layer. An example of this method is illustrated in Figure 5 and described in paragraph 31.

Claim 28 recites a method of reading information from a ferroelectric layer. The method includes using a probe to sense changes in capacitance or leakage current of the junction. An example of this method is illustrated in Figure 6a and described in paragraph 33.

Claim 29 recites a method of reading information from a ferroelectric layer. The method includes using a probe to apply an ac signal to local areas on the ferroelectric material, wherein changes in a non-linear component of a dielectric constant are detected. An example of this method is illustrated in Figure 6b and described in paragraph 34.

6. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

a. Claim 9 is rejected under 35 U.S.C. §102(b) as being anticipated by Kasanuki U.S. Patent No. 5,481,527.

b. Claim 10 is rejected under 35 U.S.C. §102(b) as being anticipated by Kasanuki.

c. Claims 11 and 28 are rejected under 35 U.S.C. §103(a) as being unpatentable over Cho U.S. Patent Publication No. 2003/0053400 in view of Kasanuki.

d. Claims 12 and 29 are rejected under 35 U.S.C. §103(a) as being unpatentable over Cho in view of Kasanuki.

e. Claim 7 is rejected under 35 U.S.C. §103(a) as being unpatentable over Cho in view of Kasanuki.

f. Claims 25 and 26 are rejected under 35 U.S.C. §102(e) as being anticipated by Gibson U.S. Publication No. 20020110074

7. ARGUMENTS

Kasanuki discloses a data storage device including a recording medium having a ferroelectric layer 3 (col. 7, lines 23-25 and 29-36) and an electrode layer 4. The electrode layer 4 may be made of a semiconductor material (col. 7, lines 25-28). Kasanuki's device further includes a conductive probe 1 having a tip (col. 7, lines 37-38). As shown in Figure 1, the ferroelectric layer 3 is between the probe tip and the electrode layer 4.

To write (record) data to the ferroelectric layer 3, a pulse voltage is applied between the probe 1 and the electrode layer 4 (col. 7, line 62 to col. 8, line 4). As a result, there is a polarization of the ferroelectric layer 3. Direction of the polarization is determined by the polarity of the pulse voltage. Kasanuki is silent about the temperature of the ferroelectric layer during a write operation.

To read (reproduce) data stored on the recording medium, a voltage is applied between the probe 1 and the electrode layer 4, and the probe 1 is scanned across the ferroelectric layer 3 (col. 7, lines 5-9). An electrostatic force acting on the electrode (due to interaction with the stored charges in the ferroelectric layer) causes a displacement of the probe 1 (col. 8, lines 13-16). Data is reconstructed from the detected displacement (col. 8, lines 17-21).

Kasanuki describes other embodiments of the data storage device. Some embodiments use a tunnel current to record and reproduce data (col. 8, lines 33-37). In a third embodiment described at col. 12, lines 8+, a current-voltage converting circuit 93 detects a tunnel current flowing from the probe 1 to the recording medium, amplifies the tunnel current, and converts it into a voltage (col. 12, lines 33-36). Detected signals are extracted as reproduced signals though a high pass filter 92 and demodulation circuit 91 (col. 12, lines 36-38).

I
REJECTION OF CLAIM 9 UNDER 35 U.S.C. §102 AS BEING ANTCIPATED BY KASANUKI

Kasanuki does not teach or suggest a circuit for causing his probe 1 to perform block and bulk erasure operations. Kasanuki's devices perform erasure the same way that information is recorded: one bit at a time. See col. 12, lines 52-56; and col. 18, lines 14-21.

The office action cites a first passages at col. 3, lines 52-58 and a second passage at col. 10, lines 53-61 of Kasanuki. The first passage discloses a circuit 7 for performing erasure, but does not teach or suggest that the circuit can perform block and bulk erasures. The relevance of the second passage is not clear, as it

only discusses the choice of material for the probe, and the necessity of a sharp probe tip.

Because Kasanuki does not teach or suggest all of the claim features of claim 9, claim 9 should be allowed over Kasanuki.

II
REJECTION OF CLAIM 10 UNDER 35 U.S.C. §102 AS BEING ANTCIPATED BY KASANUKI

Kasanuki does not teach or suggest a data storage device including means for heating the ferroelectric material above its Curie temperature. As discussed above, Kasanuki is silent about the temperature of the ferroelectric layer 3 while data is being recorded.

The office action cites a first passage at col. 3, lines 52-58, a second passage at col. 8, lines 45+, and a third passage at col. 10, lines 53-61 of Kasanuki. The first passage discusses a circuit 7 for performing recording, reproduction and erasure operations, but does not teach or suggest that the circuit 7 heats a ferroelectric layer above its Curie temperature during any of these operations. The relevance of the second passage is not clear, as it only discusses the manufacture of the electrode layer 4. The relevance of the third passage is not clear, as it only discusses the choice of material for the probe, and the necessity of a sharp probe tip.

Because Kasanuki does not teach or suggest all of the claim features of claim 10, claim 10 should be allowed over Kasanuki.

III
REJECTION OF CLAIMS 11 AND 28 UNDER 35 U.S.C. §103 AS BEING UNPATENTABLE OVER CHO IN VIEW OF KASANUKI

Cho and Kasanuki, alone and in combination, do not teach or suggest a data storage device including an electrical junction formed by a semiconductor portion and a ferroelectric layer, and a read circuit for using a probe to sense changes in capacitance or leakage current of the junction.

The office action does not reject claims 11 and 28 in view of Kasanuki alone. Therefore, the office action appears to acknowledge that Kasanuki does not teach or suggest a read circuit for using a probe to sense changes in capacitance or leakage current of the junction.

The office action cites Figures 1-5 (elements Csa to Csn) and paragraphs 71-75 of Cho. Figures 1-3 and 5 of Cho illustrate a dielectric record medium 11 including a dielectric thin film 12 on an electrode 13 (see paragraph 72). Paragraph 58 discloses that the dielectric film 12 may be made of a ferroelectric material, and paragraph 72 discloses that the electrode 13 may be formed on a silicon substrate. The dielectric thin film 12 is on one side of the electrode 13, and the silicon substrate is on the other side of the electrode. Therefore, the silicon substrate and the thin dielectric film 12 do not form an electrical junction.

According to paragraph 73, capacitances Csa to Csn are formed in a small area of the dielectric film 12 between the probes 14a-14n and the electrode 13. According to paragraph 74, an oscillator 20 oscillates as a function of these capacitances Csa to Csn. Data can be reproduced by demodulating the oscillator signal and synchronizing the demodulated signal with ac signals that are generated by ac generators 15a-15n.

The capacitances Csa to Csn are not formed by a ferroelectric layer and a semiconductor substrate. Thus, sensing changes in these capacitances does not read on claims 11 and 28. Therefore, claims 11 and 28 should be allowed over the combined teachings of Cho and Kasanuki.

Moreover, the office action finds no reason, incentive or motivation in the prior art for combining the teachings of Cho and Kasanuki. For this additional reason, the office action has not established prima facie obviousness of claims 11 and 28. Accordingly, the '103 rejection of claims 11 and 28 should be withdrawn.

IV
REJECTION OF CLAIMS 12 AND 29 UNDER 35 U.S.C. §103 AS BEING UNPATENTABLE OVER CHO IN VIEW OF KASANUKI

Cho and Kasanuki, alone and in combination, do not teach or suggest a data storage device including a read circuit for using a probe to apply an ac signal to local areas on a ferroelectric material, and detecting changes in a non-linear component of a dielectric constant.

The office action does not reject claims 12 and 29 in view of Kasanuki alone. Therefore, the office action appears to acknowledge that Kasanuki does not teach or suggest a read circuit for using a probe to apply an ac signal to local areas on a ferroelectric material, and detecting changes in a non-linear component of a dielectric constant.

The office action cites Figures 1-2, the abstract, and paragraphs 70-75 of Cho. Figures 1-2 of Cho illustrate a dielectric record medium 11 including a dielectric thin film 12 on an electrode 13 (see paragraph 72). Paragraph 58 discloses that the dielectric film 12 may be made of a ferroelectric material.

According to paragraph 73, capacitances Csa to Csn are formed in a small area of the dielectric film 12 between the probes 14a-14n and the electrode 13. According to paragraph 74, an oscillator 20 oscillates as a function of these capacitances Csa to Csn. Data can be reproduced by demodulating the oscillator signal and synchronizing the demodulated signal with ac signals that are generated by ac generators 15a-15n.

Although Cho discloses that the ac signals are applied to the probes 14a-14n, Cho does not teach or suggest detecting changes in a <u>non-linear component</u> of a dielectric constant. Therefore, claim 12 should be allowed over the combined teachings of Cho and Kasanuki.

Moreover, the office action finds no reason, incentive or motivation <u>in the prior art</u> for combining the teachings of Cho and Kasanuki. For this additional reason, the office action has not established prima facie obviousness of claims 12 and 29. Accordingly, the '103 rejection of claims 12 and 29 should be withdrawn.

V
REJECTION OF CLAIM 7 UNDER 35 U.S.C. §103 AS BEING UNPATENTABLE OVER CHO IN VIEW OF KASANUKI

Cho and Kasanuki, alone and in combination, do not teach or suggest a data storage device including a substrate, a ferroelectric layer, and a protective layer covering the ferroelectric layer.

The office action does not reject claim 7 in view of Kasanuki alone. Therefore, the office action appears to acknowledge that Kasanuki does not teach or suggest a protective layer covering the ferroelectric layer 3.

The office action cites Figure 9 (elements 81-83) and paragraph 152 of Cho. However, the only film mentioned in paragraph 152 is used for recording (a record medium 83 composed of a substrate 81 and a thin film 82 forming a recording section on the substrate). Because the combined teachings of Cho and Kasanuki do not teach or suggest a protective layer covering a ferroelectric layer, the '103 rejection of claim 7 should be withdrawn.

Moreover, the office action finds no reason, incentive or motivation <u>in the prior art</u> for combining the teachings of Cho and Kasanuki. For this additional reason, the office action has not established prima facie obviousness of claim 7. Accordingly, the '103 rejection of claim 7 should be withdrawn.

VI

REJECTION OF CLAIMS 25 AND 26 UNDER 35 U.S.C. §102 AS BEING ANTICIPATED BY GIBSON U.S. PUBLICATION NO. 20020110074

Gibson does not teach or suggest a data device having a layer of poled ferroelectric material, let alone a method of writing information to a layer of poled ferroelectric material. Gibson discloses a data storage device including a storage medium 40, a probe 10, and a fluid medium between the storage medium 40 and the probe 10 (paragraph 45). The storage medium 40, which contains nanometer-sized storage areas, may include a material capable of holding a localized charge (paragraph 57). The fluid medium 90 can be a ferrofluid that contains metallic particles 100 (paragraph 62). When the probe generates an electron beam, the resulting magnetic fields cause the particles to agglomerate and form a conducting path to the storage medium 40 (paragraph 62).

Although Gibson states that his storage medium may be made of a material that stores localized charges, he does not elaborate further on the material. The office action appears to contend that the particles 100 suspended within the fluid medium 90 constitute a poled ferromagnetic layer for storing data. Figures 3-4 and paragraph 65 are cited. However, the particles 100 do not store data, they simply provide a conductive path from the probe 10 to the storage medium 40.

Thus, Gibson does not teach or suggest a poled ferroelectric layer, let alone a method writing to such a layer. Therefore, claims 25 and 26 should be allowed over Gibson.

Moreover, Gibson does not teach or suggest heating any type of recording material above its Curie temperature during a write operation. The office action cites paragraphs 14 and 22, but these paragraphs are silent about heating a ferroelectric material to a temperature above which its dipole polarization becomes

randomized. For this additional reason, claims 25 and 26 should be allowed over Gibson.

For the reasons above, the rejections of claims 7, 9-12, 25-26 and 28-29 should be withdrawn. The Honorable Board of Patent Appeals and Interferences is respectfully requested to reverse these rejections.

Respectfully submitted,

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8. <u>CLAIMS APPENDIX</u>

Claims 1-6 (Cancelled)

7. (Previously presented) A data storage device comprising a conductive probe having a tip; a substrate including a semiconductor portion; a data storage medium including a layer of poled ferroelectric material for storing data, the ferroelectric layer on the substrate, between the tip and the substrate, the semiconductor portion and the ferroelectric layer forming an electrical junction; and a protective layer covering the ferroelectric layer, the protective layer not interfering with interactions between the probe tip and the ferroelectric layer.

Claim 8 (Cancelled)

9. (Previously presented) A data storage device comprising a conductive probe having a tip; a substrate including a semiconductor portion; a data storage medium including a layer of poled ferroelectric material for storing data, the ferroelectric layer on the substrate, between the tip and the substrate, the semiconductor portion and the ferroelectric layer forming an electrical junction; and a circuit for causing the conductive probe to perform block and bulk erasure operations.

10. (Previously presented) A data storage device comprising a conductive probe having a tip; a substrate including a semiconductor portion; a data storage medium including a layer of poled ferroelectric material for storing data, the ferroelectric layer on the substrate, between the tip and the substrate, the semiconductor portion and the ferroelectric layer forming an electrical junction; and means for heating the ferroelectric material above its Curie temperature, whereby block and bulk erasure can be performed.

11. (Previously presented) A data storage device comprising a conductive probe having a tip; a substrate including a semiconductor portion; a data storage medium including a layer of poled ferroelectric material for storing data, the ferroelectric layer on the substrate, between the tip and the substrate, the semiconductor portion and the ferroelectric layer forming an electrical junction; and a read circuit for using the probe to sense changes in capacitance or leakage current of the junction.

12. (Previously presented) A data storage device comprising a conductive probe having a tip; a substrate including a semiconductor portion; a data storage medium including a layer of poled ferroelectric material for storing data, the ferroelectric layer on the substrate, between the tip and the substrate, the semiconductor portion and the ferroelectric layer forming an electrical junction; and a read circuit for using the probe to apply an ac signal to local areas on the ferroelectric material, and detect changes in a non-linear component of a dielectric constant.

Claims 13-24 (Cancelled)

25. (Previously presented) A method of writing information to a layer of poled ferroelectric material, the method comprising using a probe to create local polarization changes in the material, the probe having a tip diameter no more than several nanometers; and heating the ferroelectric layer above its Curie temperature, whereby block erasure of the ferroelectric layer is performed.

26. (Previously presented) A method of writing information to a layer of poled ferroelectric material, the method comprising using a probe to create local polarization changes in the material, the probe having a tip diameter no more than several nanometers; and heating selected areas of the ferroelectric layer above the Curie temperature of the ferroelectric layer, whereby the areas of the ferroelectric layer are erased.

Claim 27 (Cancelled)

28. (Previously presented) A method of reading information from a ferroelectric layer that is on a semiconductor substrate, and forms an electrical junction with the semiconductor substrate, the method comprising:

scanning a surface of the ferroelectric layer with a probe having a sharp tip, the tip having a diameter of several nanometers; and

using the probe and the semiconductor substrate to detect polarity reversals at designated locations on the ferroelectric layer, each polarity reversal at a designated location indicating a first stored value at that designated location, each non-reversal of polarity at an expected location indicating a second logic value stored at that designated location;

wherein the probe is used to sense changes in capacitance or leakage current of the junction.

29. (Previously presented) A method of reading information from a ferroelectric layer that is on a semiconductor substrate, and forms an electrical junction with the semiconductor substrate, the method comprising:

scanning a surface of the ferroelectric layer with a probe having a sharp tip, the tip having a diameter of several nanometers; and

using the probe and the semiconductor substrate to detect polarity reversals at designated locations on the ferroelectric layer, each polarity reversal at a designated location indicating a first stored value at that designated location, each non-reversal of polarity at an expected location indicating a second logic value stored at that designated location;

wherein the probe is used to apply an ac signal to local areas on the ferroelectric material, and wherein changes in a non-linear component of a dielectric constant are detected.

Claims 30-37 (Cancelled)

9. <u>EVIDENCE APPENDIX</u>

None

10. <u>RELATED PROCEEDINGS APPENDIX</u>

None